



**SYSTEMS ENGINEERING**  
**Research Center**

A US DoD University Affiliated Research Center

# **Annual SERC Research Review – RT 19**

**November 9-10, 2010**

**Hosts: University of Maryland  
Fraunhofer Center  
College Park, MD**

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Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE <b>NOV 2010</b>		2. REPORT TYPE		3. DATES COVERED <b>00-00-2010 to 00-00-2010</b>	
4. TITLE AND SUBTITLE <b>Annual SERC Research Review - RT 19</b>				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Stevens Institute of Technology, Systems Engineering Research Center (SERC), 1 Castle Point on Hudson, Hoboken, NJ, 07030</b>				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release; distribution unlimited</b>					
13. SUPPLEMENTARY NOTES <b>Presented at the 2nd Annual SERC Research Review Conference, 9-10 Nov 2010, College Park, MD. SERC is sponsored by the Department of Defense. U.S. Government or Federal Rights License</b>					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>Same as Report (SAR)</b>	18. NUMBER OF PAGES <b>31</b>	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			

# **RT19: Research on Building Education & Workforce Capacity in Systems Engineering**

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# Building Education & Workforce Capacity in Systems Engineering

## Research Question

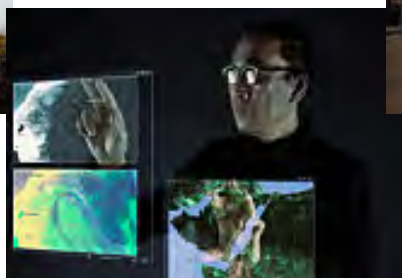
What methods, approaches, environments, and materials lead to greater SE learning, career interest, and interest in DoD problems?

## Approach

Develop course materials and other value-added SE inputs and conduct pilot courses in 14 diverse institutions; assess impacts on SE learning, career interest and interest in DoD problems among undergraduate and graduate students.

# Context for Research

- Pilot programs within UG/G capstone courses, to provide students with *substantive practical experience with SE concepts and skills, and with opportunities for the development of a final product.*
- Capstone course work will focus on *authentic DoD problems, with participation from DoD representatives in teams' projects*



# Deliverables

- Analysis of learning outcomes by principal investigators of individual pilot programs based on progress as of January 2011 and June 2011.
- Compilation, synthesis and analysis of learning outcomes from the pilot programs for project periods through January 2011 and June 2011.
- Recommendations based on the pilot programs that will inform the development of a larger scale-up effort to build capacity for SE learning nationwide.



# *The Value of Systems Engineering Capstone Courses*

**Dr. Laura Adolfie**  
**Director, STEM Development Office**  
**DDR&E/ Research Directorate**

**2<sup>nd</sup> Annual SERC Research Review**  
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# Systems Engineering Mission



- Develop and grow the Systems Engineering capability of the Department of Defense
- A robust Systems Engineering capability across the Department requires attention to Policy, People, and Practice
- We apply best engineering practices to:
  - Support and advocate for DoD Component initiatives
  - Help program managers identify and mitigate risks
  - Shape technical planning and management
  - Provide technical insight to OSD stakeholders
  - Identify systemic issues for resolution above the program level



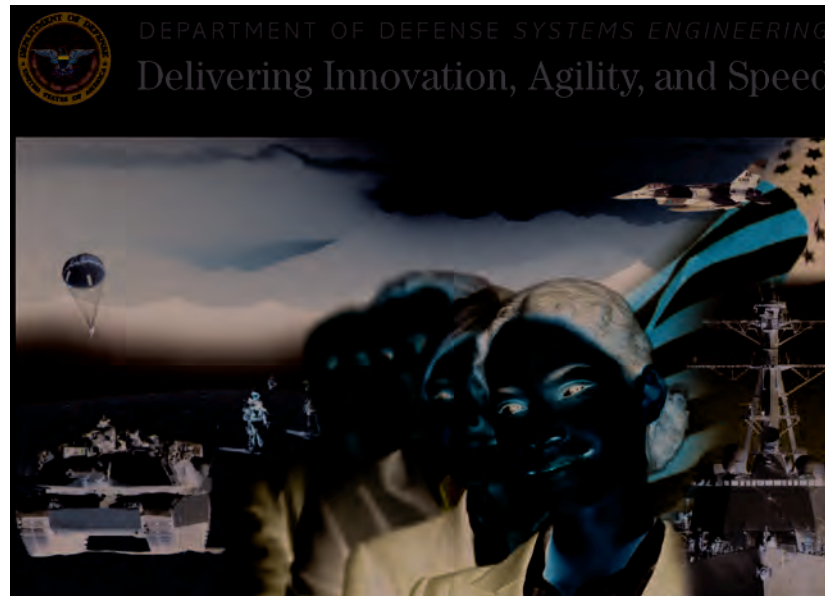




# Focus Areas for DDR&E: *Improving the Department's Engineering Practice*



- Growing the Systems Engineering Workforce
- Improving SE Capabilities in DoD and the Defense Industrial Base
- Growing our Nation's Future SE Workforce



Our Focus: Policy, People and Practice



# What Are Our Expectations of Our Systems Engineering Workforce?

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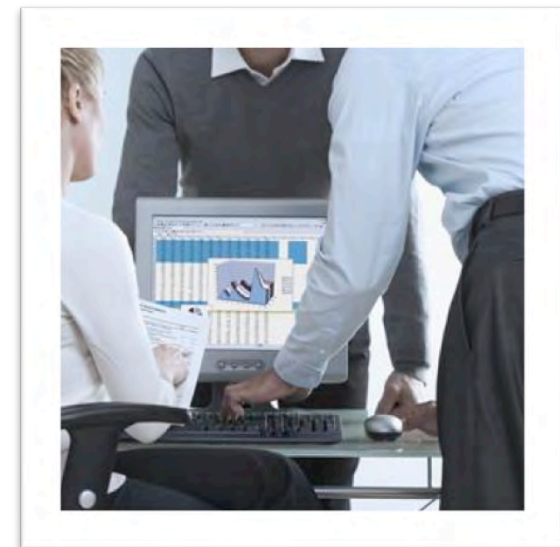
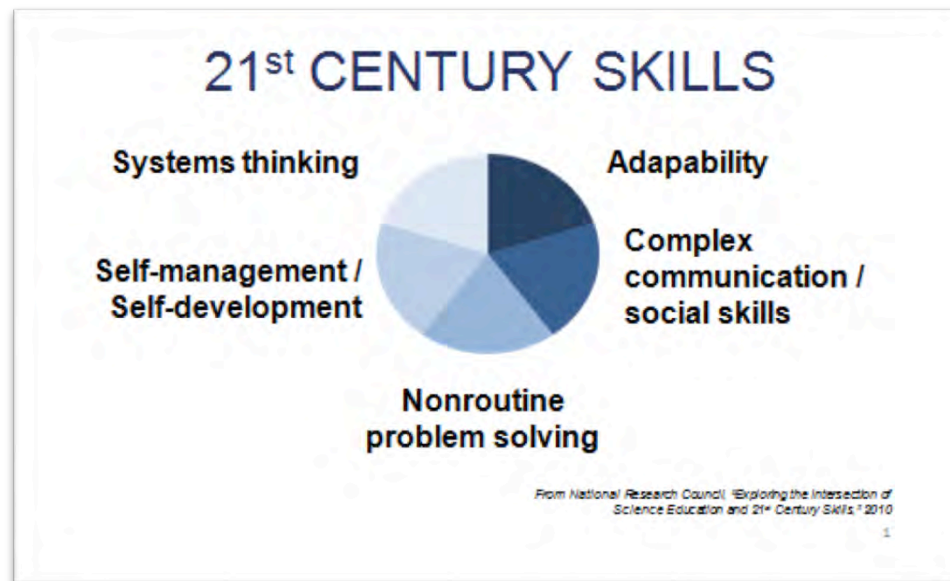
- Breadth
- Depth
- Leadership



# We Need Systems Thinkers with Real World Context



- Today's technology systems are extremely complex, cross-disciplinary, somewhat non-deterministic, and rarely standalone
- We give student opportunities to have an authentic DoD experience:
  - Work on real DoD projects
  - Interact with DoD and Defense Industry mentors





# Service Academy Participation



- Air Force Institute of Technology and Naval Postgraduate School manage:
  - US Air Force Academy
  - US Military Academy
  - US Naval Academy
  - US Coast Guard Academy
- Allows separate but aligned efforts with the 8 civilian SERC schools
- Targets future engineering officers in the Services





# Sponsor Goals for the Program



- Expose graduating undergraduate/early Masters students to DoD SE topics
- Test innovative ways to insert DoD content into curricula
- Increase numbers of SEs who can enter DoD workforce quickly
  - DoD Laboratory Enterprise
  - DoD Acquisition Programs & Offices
  - Defense Contractors



# Methodology



- Operate Pilot at 8 civilian universities & 6 service academies/military graduate institutions
- SE Capstone course design
  - 1<sup>st</sup> semester lecture/seminar course
  - 2<sup>nd</sup> semester project
- Project Teams select from 4 project areas
  - Immersive Training
  - Low Cost Computing
  - Expeditionary Green Housing
  - Expeditionary Operations
- Project Teams work with mentors
  - DoD
  - Defense Primes
- SERC to collect and report “Lessons Learned”
- Program Deliverables
  - Syllabi
  - Progress Reports
  - Project Outcomes/Papers & Outbriefs
  - “Lessons Learned” with recommendations for paths forward



# SE Capstone Student Projects



- Project descriptions available for review at:

[http://www.sercuarc.org/fileadmin/sercuarc/SERC\\_Publications/  
SE\\_Capstone\\_Summaries\\_All\\_ASRR\\_27Oct10.pdf](http://www.sercuarc.org/fileadmin/sercuarc/SERC_Publications/SE_Capstone_Summaries_All_ASRR_27Oct10.pdf)





# Sponsor Focus

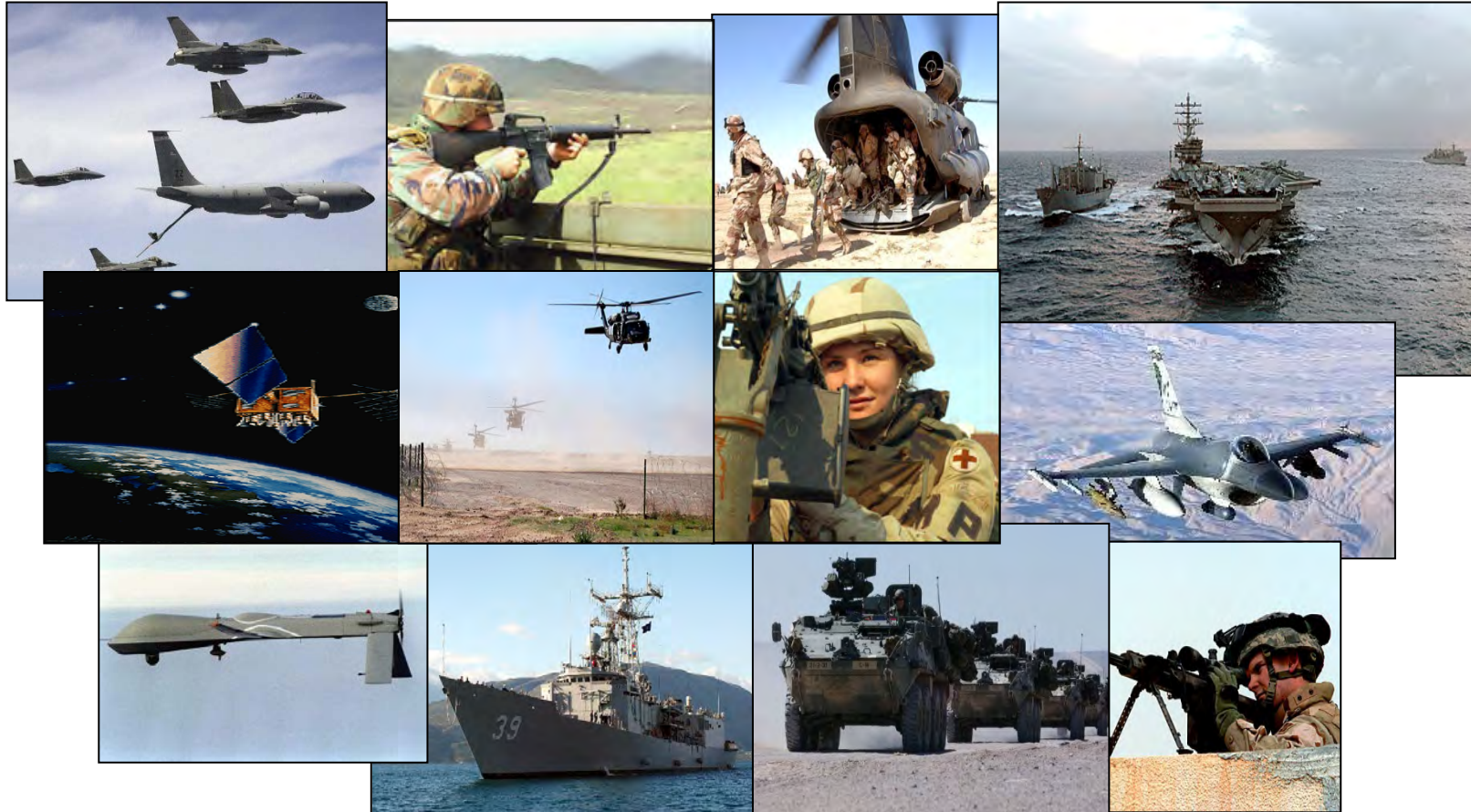


- Provide Access & Opportunities that Build Student Interest
- Provide Mentors from Government & Defense Industry for all Teams
  - Foster Long-Term Relationships
  - Build Community of Interest & Practice
- Track and Assess Quality/Quantity of Mentor Involvement





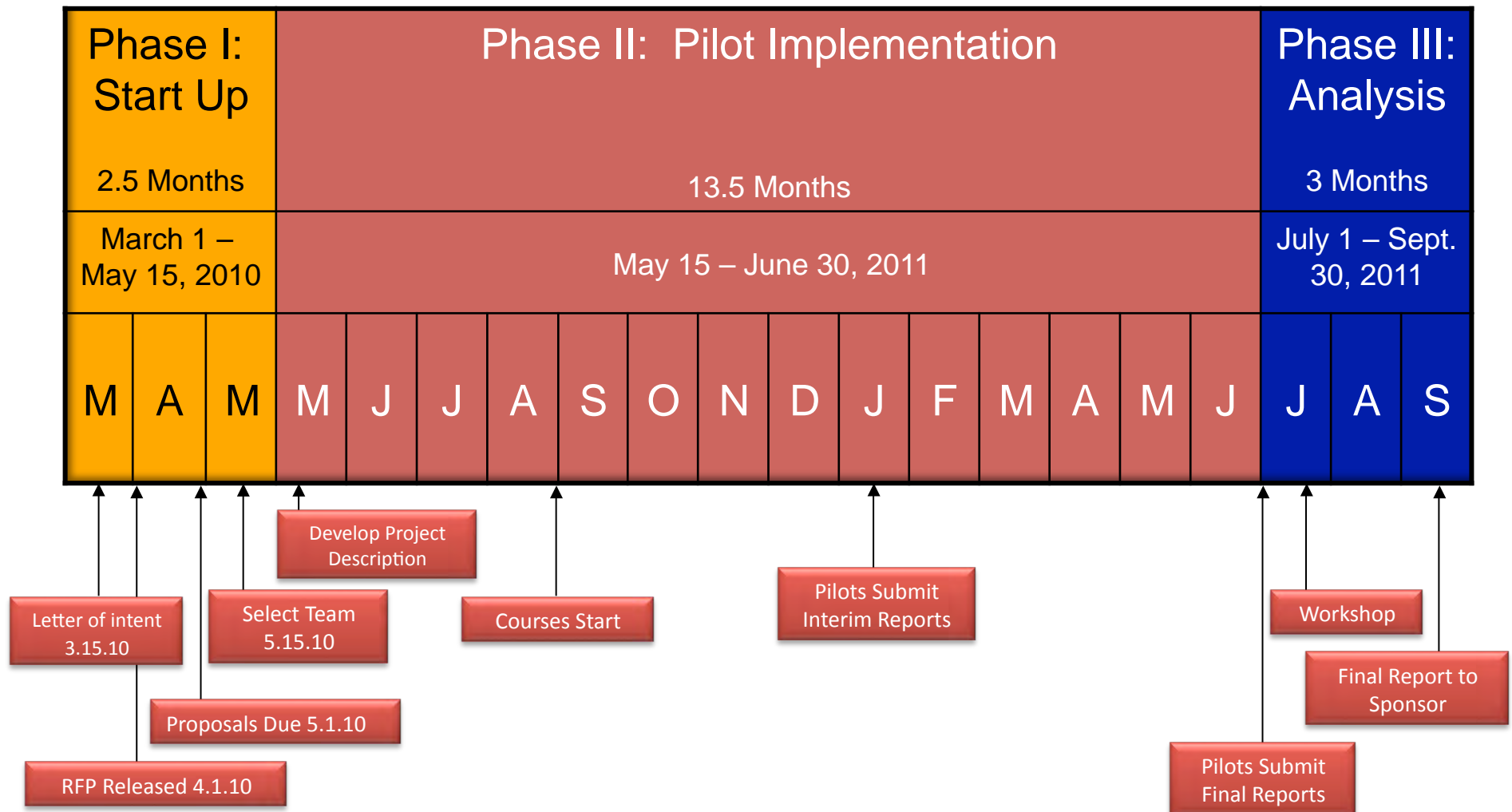
# Systems Engineering: Critical to DoD Success



*Innovation, Speed, and Agility*

<http://www.dod.mil/ddre/stem>

# Project Schedule



# Partners

## Civilian Universities

1. Auburn University
2. Missouri University S & T
3. Penn State
4. Southern Methodist University
5. Stevens Institute of Technology
6. University of Maryland
7. University of Virginia
8. Wayne State



## Service Academies

1. Air Force Institute of Technology
2. Naval Postgraduate School
3. Air Force Academy
4. Military Academy – West Point
5. Coast Guard Academy
6. Naval Academy



# What we hope to learn

- Common elements across diverse set of projects that lead to increased SE knowledge, career interest, and interest in DoD problems.
- Differing effects and outcomes between civilian and military institutions, undergraduate and graduate students, other differentiators.
- Differential effects of DoD mentor involvement (preliminary).
- Differential impacts and lessons learned from varied approaches to recruitment, course organization, team composition, etc.
- Recommendations for core elements of success for scaling up

# Measurement of Student Educational Outcomes

## Required Common Assessments

- Pre/Post Survey
  - Knowledge of SE
  - Interest in SE Careers
  - Awareness of DoD problem areas
- Pre/Post Case Student Analysis (Bradley Fighting Vehicle)
  - Growth in SE approach/Analysis (semantic analysis)
- Weekly Blog Posts
  - Qualitative
  - Progress in level of sophistication of student analysis
  - Final blog post-cumulative

# Measurement of Student Educational Outcomes

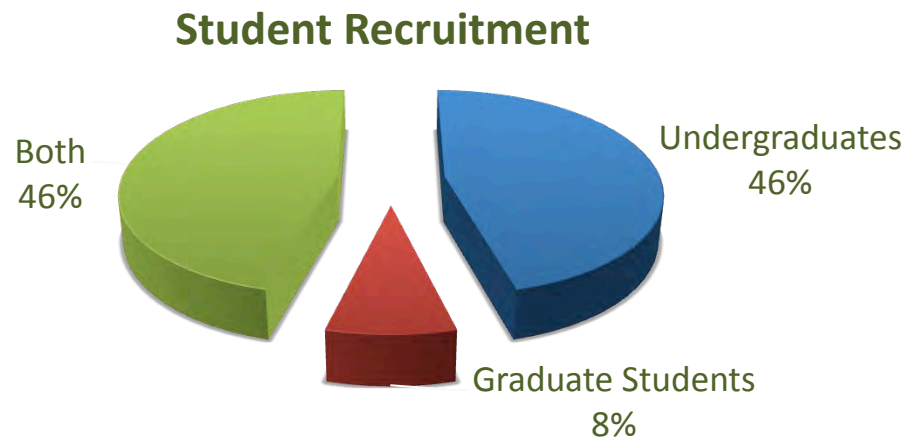
## Customized Assessments

- Faculty-developed assessments unique to their courses
- PI Evaluation of course effectiveness
- PI Reports on DoD and Industry Mentors

# Preliminary Data

- Student Recruitment
- Problem Area Selection
- Teams
- Role of Graduate Students
- DoD Mentor Impact
- Early Lessons

# Most Schools Made the DoD Project a Choice for Students Doing Capstone Projects



- Why did students choose to participate?
  - Students interested in specific problem area
  - Students interested in working on a project sponsored by the DoD

*NOTE: 13 Partner institutions provided feedback on this preliminary PI.*



# Problem Areas and Teams

- Problem Area Selection Criteria:
  - Faculty members with expertise in a particular area were available and interested
  - Problem area considered to be related to a social concern and would attract students
  - Partner institutions had ongoing project in that area
- Teams:
  - Wide range in the number of teams at each partner institution – from 1 to 10, with an average of four
  - Team size range – 2 to 24 students; most teams formed by 5 students

# Involvement of Graduate Students

- Undergraduates benefit from graduate students' experience
- Serve as role models and provide guidance to undergraduates
- “We also included distance education graduate students in our course. This is valuable in that it requires the team to coordinate their work in advance, communicate effectively, and use virtual collaboration tools”

# DoD Mentors' Impact to Date

On a scale of 1 to 5, with 1 being “completely disagree” and 5 being “completely agree,” how much do you agree or disagree that having a DoD mentor has had a significant impact on...

	1	2	3	4	5	
<b>Student Motivation</b>	0	0	17%	17%	67%	100%
<b>Student Learning</b>	0	0	33%	50%	17%	100%

# DoD Mentors' Impact to Date

On a scale of 1 to 5, with 1 being “completely disagree” and 5 being “completely agree,” how much do you agree or disagree that having a DoD mentor has had a significant impact on...

Degree of Involvement	Number of Schools
Very involved	2
Somewhat involved	5
We have a mentor, but we have not worked with him/her yet	2
We do not have a mentor yet	4

*NOTE: Timeline for coursework implementation varies from one school to another.*

# DoD Mentors Impact to Date

## Described by Pls

- “He was able to go over conceptual design review for each team and answered many questions from students”
- “Having the students interact with the sponsors on a weekly basis helps keep them focused on the tasks. It also gives students experience in dealing with project reporting”
- “Provides realistic views on the system, its functionality and requirements. Provides feedback and critique”

# PI Suggestions to Improve the Mentor Role in the Future

- “The role of the mentor should be clarified. In some cases the DoD mentor serves as a primary stakeholder but in other cases the mentor serves as an advisor guiding students to a solution. Blurring these two roles can lead to a confusion”
- “It should be clear to mentors that the primary objective is to provide high quality learning experience for the students, not to develop a design that will prove to be useful”
- “We should have had an assigned mentor as we were submitting the proposal to guide us in how we went from initial concept up through marketing to students and product research and development”

# Lessons Learned

- Need for more planning time:
  - To review project definitions and clarify the roles of the mentors and faculty
  - Earlier allocation of DoD mentors
  - Aligning schedules and academic requirements across departments has been a challenge due to the scope and multi-disciplinary nature of the project. A project manager would be helpful
- Better planning for IRB approval:
  - Recommendation for a joint protocol and informed consent process
- Suggestions for current pilot program:
  - Organized visits to outside facilities, either on-site or electronic/virtual
  - Students meeting with mentors outside the gates of their institution



# Next Steps

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- January 2011 Interim Report with preliminary findings and internal course evaluations
- June 2011 Final Reports and July 2011 Workshop
- Analysis and Synthesis of Learning Outcomes from the Pilot Programs
- Recommendations based on the Pilot Programs that will inform the development of a scale-up effort to build SE capacity
- Establish mechanism to monitor student/mentor/faculty relationships